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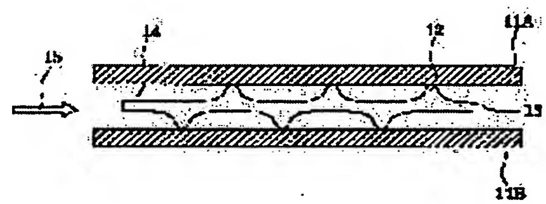
(54) PLASMA REACTION VESSEL AND METHOD FOR DECOMPOSING GAS BY PLASMA

(57)Abstract:

PROBLEM TO BE SOLVED: To enhance the efficiency of a reaction by uniformizing the flow velocity distribution of the gas passing in the reaction vessel and prolonging the stay of the gas in the plasma at a position with high-flow velocity part (center of space).



SOLUTION: This plasma reaction vessel is provided with the first flat-plate electrode and second flat-plate electrode opposed to each other, a dielectric interposed between the electrodes and a means for imparting a potential difference between the electrodes. A high voltage is impressed between the electrodes to decompose the gas in the plasma decomposition region between the electrodes, and plural protrusions are formed on one or both sides of the dielectric.

LEGAL STATUS

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* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The 1st monotonous mold electrode and the 2nd monotonous mold electrode which carry out phase opposite, and the dielectric infixed in inter-electrode [these / 1st and 2nd], In the plasma reaction container which decomposes the gas which came to have a potential difference grant means to give the potential difference to inter-electrode [said / 1st and 2nd], and impressed and introduced the high voltage into inter-electrode [said / 1st and 2nd] in an inter-electrode plasma decomposition field The plasma reaction container characterized by coming to form two or more heights in surface both sides or surface either of said dielectrics.
[Claim 2] The plasma reaction container characterized by making into one unit the 1st and 2nd electrodes which infixed said dielectric in claim 1, and coming to carry out the laminating of two or more these units.
[Claim 3] The plasma reaction container characterized by sharing one [at least] electrode of an adjoining unit in claim 2.
[Claim 4] The plasma reaction container characterized by the flat-surface configuration of the height which set they to be [any of claims 1-3], and was formed in the front face of said dielectric being a rhombus, a polygon, a circle, an ellipse, or elliptical.
[Claim 5] The plasma reaction container characterized by setting they being [any of claims 1-4], and a part of height of the height formed in the front face of said dielectric differing.
[Claim 6] It is the plasma reaction container which sets they to be [any of claims 1-5], and is characterized by said dielectric being in said the 1st and 2nd at least one side and non-contact conditions of an electrode.
[Claim 7] The plasma reaction container characterized by setting they being [any of claims 1-5], and said dielectric and said 1st and 2nd electrodes touching.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is efficient and relates to the plasma reaction container and the gas plasma decomposition approach of reforming gas by plasma treatment.
[0002]
[Description of the Prior Art] From the former, it is contamination gas in an environment (for example, the gas plasma decomposition art by discharge (silent discharge, barrier discharge) is known as an approach of purifying NOX and VOC (harmful matter, such as an volatile organic compound, Volatile Organic Compound, and ethylene).).
[0003] Hereafter, the plasma treatment approach of this conventional gas is explained. Drawing 12 is the block diagram of the parallel monotonous mold gas reactor which performs gas plasma treatment. As shown in drawing 12 , the conventional parallel monotonous mold gas reactor consists of parallel metal monotonous mold electrodes 01A and 01B which counter, a dielectric 02 which it comes to allot to the front face of one electrode (drawing Nakashita side side) 01B, and a high voltage power supply 03 which impresses the high voltage to said inter-electrode 01A and 01B, and the discharge space 04 formed in inter-electrode is made to generate plasma discharge. According to this equipment, by impressing the alternating current high voltage from a high voltage power supply 03 between electrode 01A and 01B, the aggregate of a minute discharge column is formed in inter-electrode, the silent discharge which spread uniformly in plate-like seemingly occurs, and plasma decomposition processing is made by supplying the gas 05 decomposed into discharge space 04. This silent discharge can raise the contact probability (ionization of gas, excitation probability) of the plasma and gas to general lightning discharge by ordinary pressure discharge, and is supposed that improvement in conversion can be aimed at.
[0004] thus, the thing using the silent discharge which inserted the dielectric in inter-electrode -- near atmospheric pressure -- the discharge volume can be comparatively expanded to the bottom of high gas pressure, consequently the plasma-ized probability of inflow gas increases, and a gas reaction (decomposition) can be performed efficiently.
[0005]
[Problem(s) to be Solved by the Invention] However, with the parallel monotonous mold reaction container concerning the conventional technique, there is a problem that a velocity distribution becomes an ununiformity by making an electrode into a laminated structure etc. since a difference has the velocity distribution of the gas 05 which passes through the inside of a reaction container in a gas flow rate by part for the core near discharge sky Mabe's electrode as shown in drawing 13 although it is easy to attain miniaturization of a reaction container. Consequently, the residence time of the gas 05 in the plasma of the high rate-of-flow section (space core) becomes short, and there is a problem that an efficient reaction cannot be performed.
[0006]
[Means for Solving the Problem] The 1st monotonous mold electrode and the 2nd monotonous mold electrode in which the 1st mode of this invention which solves said technical problem carries out phase opposite, Come to have the dielectric infixed in inter-electrode [these / 1st and 2nd], and a potential difference grant means to give the potential difference to inter-electrode [said / 1st and 2nd], and the high voltage is impressed to inter-electrode [said / 1st and 2nd]. It is in the plasma

reaction container characterized by coming to form two or more heights in surface both sides or surface either of said dielectrics in the plasma reaction container which decomposes the introduced gas in an inter-electrode plasma decomposition field.

[0007] The 2nd mode of this invention is in the plasma reaction container characterized by making into one unit the 1st and 2nd electrodes which infixed said dielectric, and coming to carry out the laminating of two or more these units in the 1st mode.

[0008] The 3rd mode of this invention is in the plasma reaction container characterized by sharing one [at least] electrode of an adjoining unit in the 2nd mode.

[0009] the 4th mode of this invention -- the 1-3rd voice -- it sets they to be [any / like] and is in the plasma reaction container characterized by the flat-surface configuration of the height formed in the front face of said dielectric being a rhombus, a polygon, a circle, an ellipse, or elliptical.

[0010] The 5th mode of this invention is set they to be [any of the 1-4th modes], and is in the plasma reaction container characterized by a part of height of the height formed in the front face of said dielectric differing.

[0011] The 6th mode of this invention is set they to be [any of the 1-5th modes], and said dielectric is in the plasma reaction container characterized by being in said the 1st and 2nd at least one side and non-contact conditions of an electrode.

[0012] The 7th mode of this invention is in the plasma reaction container characterized by said dielectric and said 1st and 2nd electrodes touching in which 1-5th modes.

[0013]

[Embodiment of the Invention] Hereafter, although the gestalt of operation of this invention is explained, this invention is not limited to this.

[0014] (Gestalt of the 1st operation) The schematic diagram of the gas reactor concerning the gestalt of this operation to drawing 1 is shown. Drawing 2 is the schematic diagram showing the class of height.

[0015] As shown in drawing 1 , the gas reactor concerning the gestalt of this operation consists of dielectrics 13 which have the height 12 on a front face while being infixed between the 1st electrode 11A and 2nd electrode 11B which carry out phase opposite and which are a metal monotonous mold, and these electrode 11A and 11B. The height 12 of a dielectric 13 is in the condition of having contacted the 1st and 2nd electrodes 11A and 11B, with this operation gestalt.

[0016] Moreover, among said electrodes 11A and 11B, the gas by which reforming of the gas was carried out by making plasma treatment within discharge sky Mabe 14, and reforming of the gas 15 which plasma discharge was generated and was introduced in discharge space 14 by impressing alternating voltage from the power supply unit which is not illustrated was carried out is discharged.

[0017] Since the height is formed, as a result of according to this equipment the introduced gas colliding with this height 12, slowing down a gas flow rate as a result and a gas flow rate's becoming uniform, elongation and plasma treatment effectiveness improve as a whole rather than the case where the residence time in discharge space 14 is a smooth side. Moreover, the field strength of the height increases, the compound barrier discharge in which under two or more discharge similar to strong partial intensive discharge of the quantity of light is intermingled is easy to be formed during barrier discharge, and a reaction is promoted.

[0018] When the height 12 prepared in the dielectric 13 does not need to be formed in both sides, you may make it form only in one side here.

[0019] In addition, the configuration which especially the configuration of the height 12 is not limited and can raise gas collision frequency, For example, what has arranged aslant height 12B of an ellipse form as shown in the height of the shape of the shape of stellate and a triangle and drawing 2 (b) other than height 12A of a circle configuration as shown in drawing 2 (a), and serpentine height 12C as shown in drawing 2 (c) can be illustrated. Moreover, the shape of a rhombus configuration and a polygon, elliptical, etc. are good also as a convex configuration of arbitration suitably.

[0020] (Gestalt of the 2nd operation) The schematic diagram of the gas reactor concerning the gestalt of this operation to drawing 3 is shown.

[0021] As shown in drawing 3 , only one side (drawing Nakashita side) of the height 12 by which the gas reactor concerning the gestalt of this operation was formed in the dielectric front face is in contact with 2nd electrode 11B. Since it is the same as that of the 1st operation gestalt except it, a

same sign is attached and explanation of a member is omitted.
[0022] The collision frequency of the introduced gas molecule is raised by this operation gestalt, and, thereby, improvement in reaction effectiveness can be aimed at according to it.
[0023] (Gestalt of the 3rd operation) The schematic diagram of the gas reactor concerning the gestalt of this operation to drawing 4 is shown.
[0024] As shown in drawing 4 , the both sides of the height 12 formed in the dielectric front face are changing the gas reactor concerning the gestalt of this operation into the non-contact condition which is distant from the electrode surface which carries out phase opposite. Since it is the same as that of the 1st operation gestalt except it, a same sign is attached and explanation of a member is omitted.
[0025] The collision frequency of the introduced gas molecule is raised by this operation gestalt, and, thereby, improvement in reaction effectiveness can be aimed at according to it.
[0026] (Gestalt of the 4th operation) The important section schematic diagram of the gas reactor concerning the gestalt of this operation to drawing 5 is shown.
[0027] As shown in drawing 5 , the gas reactor concerning the gestalt of this operation comes to arrange the height 17 which comes it low to carry out a part of height of the height 12, forms a part of strong electric-field section between 1st metal plate electrode 11A, makes partial discharge generate, and can generate compound barrier discharge with silent discharge.
[0028] Thus, compound barrier discharge with fog-like barrier discharge and thunder-like partial intensive discharge is attained, and improvement in plasma energy level is aimed at, and the collision frequency of the gas molecule introduced by existence of gas decomposition is raised, and he is trying for this to aim at improvement in gas reaction effectiveness by making two or more heights 12 arrange the height 17 with low height in part according to this operation gestalt.
[0029] Although the suitable example of this invention is explained hereafter, this invention is not limited to these examples at all.
[0030] (Example 1) The decomposition effectiveness of the gas by difference of the energization location to an electrode was measured using equipment as shown in drawing 6 .
[0031] Exam equipment consists of the gas blender 22 which mixes two or more gas 1, 2, and 3, a plasma reactor 23 which supplies mixed gas and performs plasma decomposition processing, a high voltage power supply 24 which impresses the high voltage to this plasma reactor, and a gas analyser 25 which measures the decomposed gas, as shown in drawing 6 .
[0032] The configuration of the height 12 formed in a dielectric front face was variously changed, as shown in drawing 7 - drawing 9 , and the decomposition trial of CO2 was performed using each. The test result of this example is shown in Table 1 and drawing 10 .
[0033] CO2 gas decomposition conditions concerning this example are shown below.
- Gas presentation : CO2(10%)+O2(10%)/N2 (balance)
- quantity-of-gas-flow: -- a part for 200-1000 cc/- intentional neurosis: -- the decomposition reaction (CO2 ->CO+1 / 2O2) of CO2
- a reaction container format and electrode dimension: -- 20mmx50mm dielectric quality-of-the-material: -- AL2O3 reaction bottle object product: -- 286 cc [0034] (1) A dielectric with the height (one side, circle configuration) (single-sided contact) (refer to drawing 7)
dielectric thickness: -- 0.5mm height height: -- diameter of 0.25mm height: -- 2mm [0035] (2) A dielectric with the height (both sides, circle configuration) (both-sides non-contact) (refer to drawing 8)
dielectric thickness: -- 0.5mm height height: -- 0.25mm [0036] (3) A dielectric with the height (one side, ellipse configuration) (both-sides contact) (drawing 9 referring-to-])
dielectric thickness: -- 0.5mm height height: -- diameter of 0.25mm height: -- 2mm (minor axis) and 3mm (major axis)
[0037] (4) Smooth side dielectric (refer to drawing 12)
Dielectric thickness: 0.5mm [0038]
[Table 1]

	ガス流量 (mL/min)				
	200	400	600	800	1000
(4) (従来法)	8	4.1	1.7	0.8	0.6
(1)	24.3	18.2	13.6	11.9	10.5
(2)	29.5	23.1	18.1	15.3	12.8
(3)	35.4	25.9	20.9	18	16.4

[0039] As shown in Table 1 and drawing 10 , when the height of (1) to (3) was formed, as compared with the conventional thing of (4), each plasma gas cracking severity was high.
[0040] Moreover, high conversion was shown although the reaction container of (3) and (4) concerning this invention had less discharge volume than the container of (2).
[0041] (Example 2) The decomposition trial of NOX was performed using the various plasma reaction containers of (4) from the above (1).
[0042] The NOX gas decomposition conditions concerning this example are shown below.
- Gas presentation : NO(500 ppm)+O2(10%)/N2 (balance)
- quantity-of-gas-flow: -- a part for 500 cc/- power-source: -- an electrical potential difference (2.8kVp), a frequency (10kHz), and a wave (square wave)
Dielectric quality of the material: aluminum 2O3 (it arranges to an earth side electrode side)
dielectric thickness: -- 0.5mm electrode quality-of-the-material: -- SUS electrode dimension: -- 50mmx20mm (a longitudinal direction is a gas flow direction)
Discharge spacing: 1.5mm [0043] The test result of this example is shown in Table 2 and drawing 11 .
[0044]
[Table 2]

	ガス流量 (mL/min)				
	200	400	600	800	1000
(4) (従来法)	26	14	6	2	1
(1)	79	68	61	58	56
(2)	88	82	78	75	73
(3)	100	95	92	89	87

[0045] As shown in Table 2 and drawing 11 , when the height of (1) to (3) was formed, as compared with the conventional thing of (4), each plasma gas cracking severity was high.
[0046] Moreover, high conversion was shown although the reaction container of (3) and (4) concerning this invention had less discharge volume than the container of (2).
[0047]
[Effect of the Invention] Since the height is formed on the surface of the dielectric according to this invention, the introduced gas will collide with this height, as a result, a gas flow rate is slowed down, a gas flow rate becomes uniform, elongation and plasma treatment effectiveness improve as a whole, it is efficient and reforming of gas becomes possible from the case where the residence time in discharge space is a smooth side.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the schematic diagram of the plasma reaction container concerning the gestalt of the 1st operation.
[Drawing 2] It is the schematic diagram showing the configuration of the height.
[Drawing 3] It is the schematic diagram of the plasma reaction container concerning the gestalt of the 2nd operation.
[Drawing 4] It is the schematic diagram of the plasma reaction container concerning the gestalt of the 3rd operation.
[Drawing 5] It is the schematic diagram of the plasma reaction container concerning the gestalt of the 4th operation.
[Drawing 6] It is the schematic diagram of a testing device at this example.
[Drawing 7] It is drawing showing the configuration of the height concerning this example.
[Drawing 8] It is drawing showing the configuration of the height concerning this example.
[Drawing 9] It is drawing showing the configuration of the height concerning this example.
[Drawing 10] It is the graph of CO2 cracking severity concerning an example.
[Drawing 11] It is the graph of the cracking severity of NOX concerning an example.
[Drawing 12] It is the schematic diagram of an parallel monotonous mold reaction container.
[Drawing 13] It is the schematic diagram of the rate of flow of the gas in an parallel monotonous mold reaction container.
[Description of Notations]
11A The 1st metal monotonous mold electrode
11B The 2nd metal monotonous mold electrode
12 Dielectric
13 Power Source
14 Discharge Sky Mabe
15 Gas

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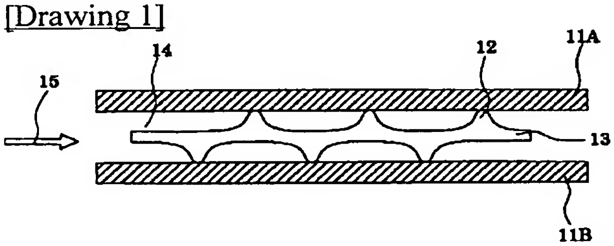
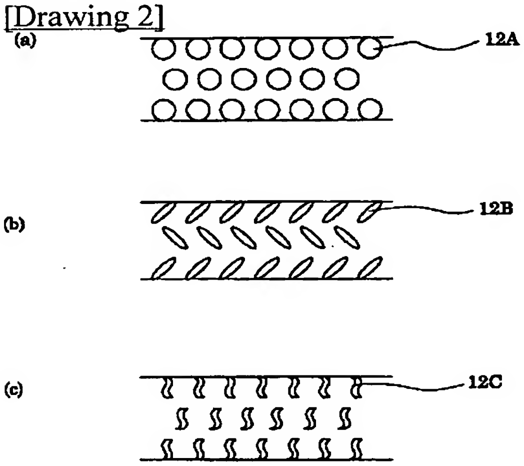
DRAWINGS

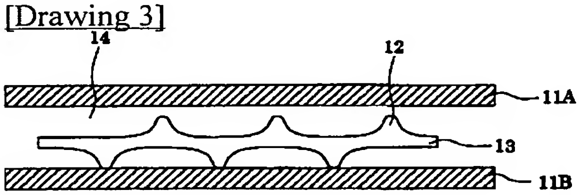
[Drawing 1]



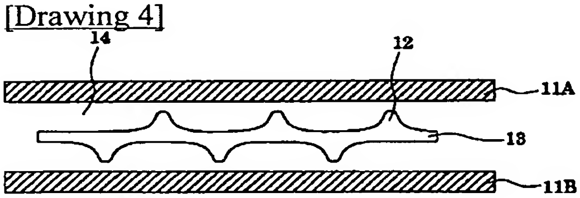
[Drawing 2]



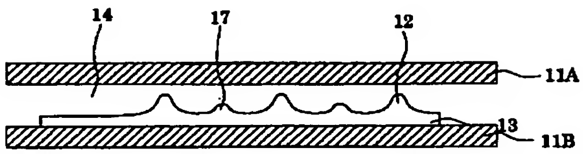
[Drawing 3]



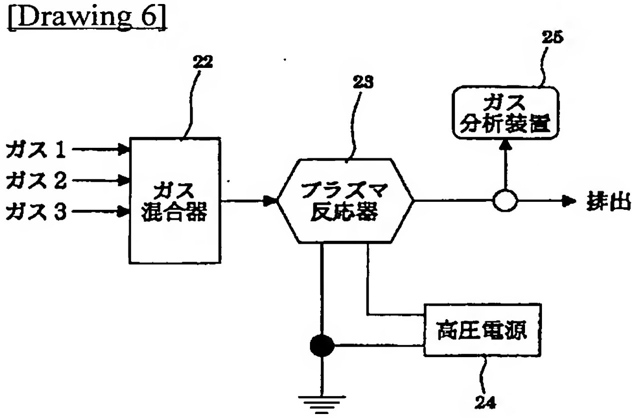
[Drawing 4]



[Drawing 5]



[Drawing 6]



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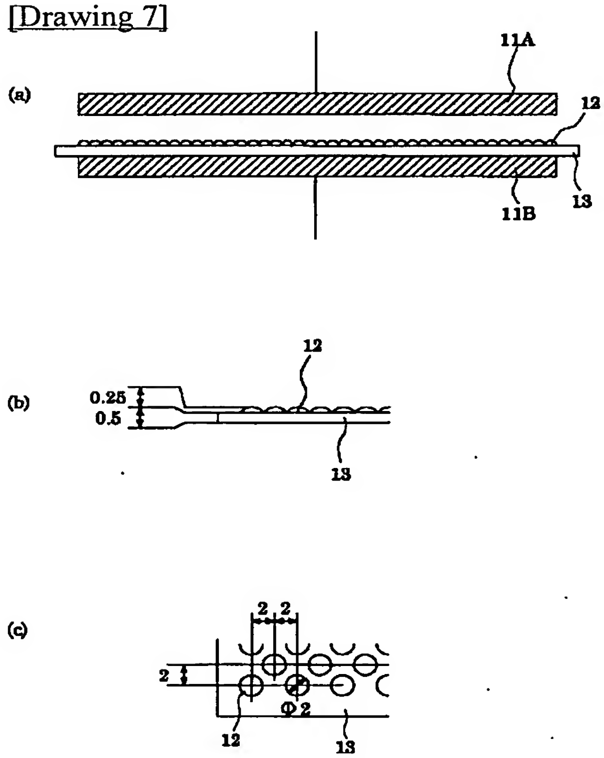
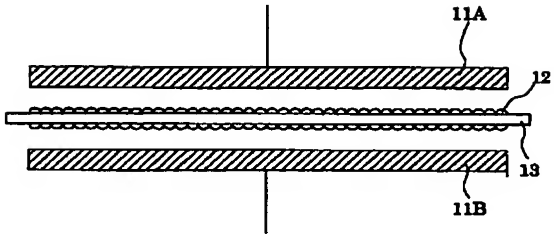


[Drawing 8]

(a)



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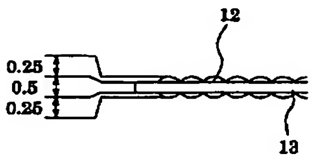

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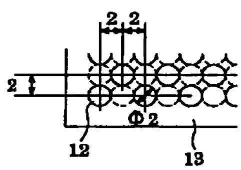
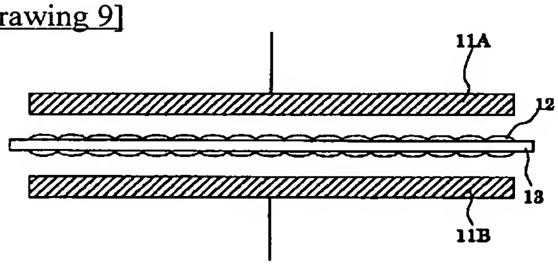


[Drawing 9]

(a)



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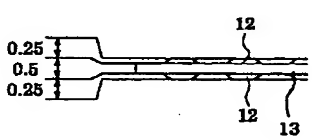

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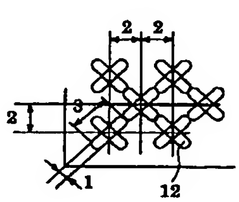
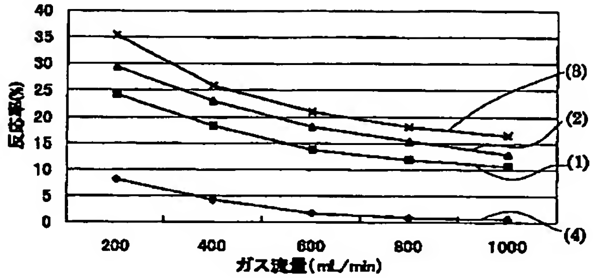
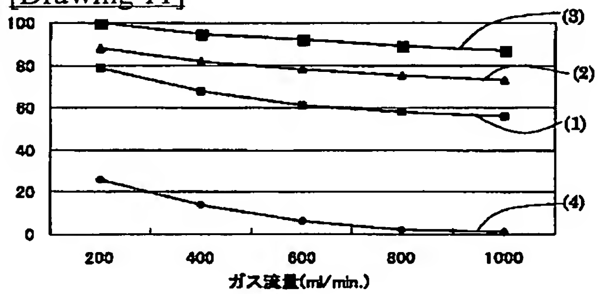


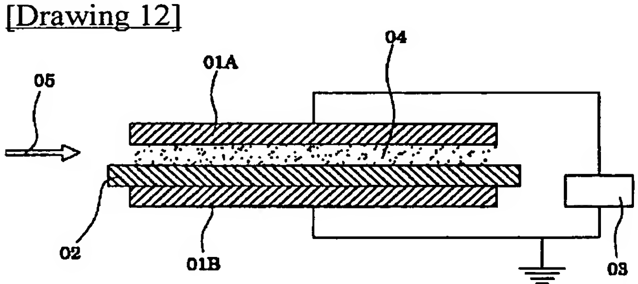
[Drawing 10]



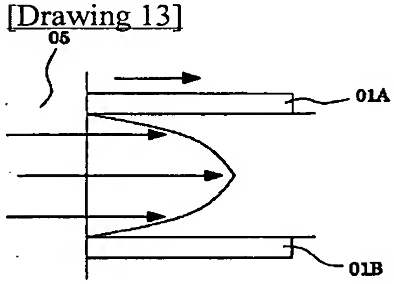
[Drawing 11]



[Drawing 12]



[Drawing 13]



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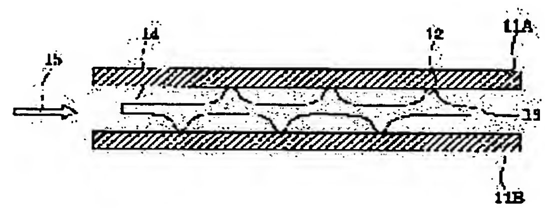
PROBLEM TO BE SOLVED: To enhance the efficiency of a reaction by uniformizing the flow velocity distribution of the gas passing in the reaction vessel and prolonging the stay of the gas in the plasma at a position with high-flow velocity part (center of space).
SOLUTION: This plasma reaction vessel is provided with the first flat-plate electrode and second flat-plate electrode opposed to each other, a dielectric interposed between the electrodes and a means for imparting a potential difference between the electrodes. A high voltage is impressed between the electrodes to decompose the gas in the plasma decomposition region between the electrodes, and plural protrusions are formed on one or both sides of the dielectric.



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1/46		1/46	Ｍ
// ＣＯ１Ｂ 31/18		ＣＯ１Ｂ 31/18	Ａ

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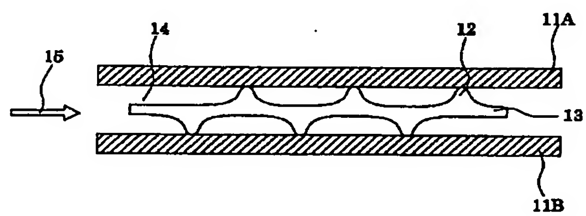
最終頁に続く

(54)【発明の名称】 プラズマ反応容器及びガスプラズマ分解方法

(57)【要約】

【課題】 反応容器内を通過するガスの流速分布を均一とし、高流速部（空間中心部）のプラズマ中におけるガスの滞在時間を長くすることによって、反応の高効率化を図る。

【解決手段】 相対向する第１の平板型電極及び第２の平板型電極と、これら第１及び第２の電極間に介装される誘電体と、前記第１及び第２の電極間に電位差を付与する電位差付与手段とを備えてなり、前記第１及び第２の電極間に高電圧を印加して導入したガスを電極間のプラズマ分解領域で分解するプラズマ反応容器において、前記誘電体の表面の両面またはいずれか一方に凸状部を複数形成する。



【特許請求の範囲】

【請求項１】　相対向する第１の平板型電極及び第２の平板型電極と、これら第１及び第２の電極間に介装される誘電体と、前記第１及び第２の電極間に電位差を付与する電位差付与手段とを備えてなり、前記第１及び第２の電極間に高電圧を印加して導入したガスを電極間のプラズマ分解領域で分解するプラズマ反応容器において、前記誘電体の表面の両面またはいずれか一方に凸状部を複数形成してなることを特徴とするプラズマ反応容器。

【請求項２】　請求項１において、前記誘電体を介装した第１及び第２の電極を１ユニットとし、該ユニットを複数個積層してなることを特徴とするプラズマ反応容器。

【請求項３】　請求項２において、隣接するユニットの少なくとも一方の電極が共有されていることを特徴とするプラズマ反応容器。

【請求項４】　請求項１～３の何れかにおいて、前記誘電体の表面に形成した凸状部の平面形状が菱形、多角形、円、長円、楕円形状のいずれかであることを特徴とするプラズマ反応容器。

【請求項５】　請求項１～４の何れかにおいて、前記誘電体の表面に形成した凸状部の高さが一部異なることを特徴とするプラズマ反応容器。

【請求項６】　請求項１～５の何れかにおいて、前記誘電体は、前記第１及び第２の電極の少なくとも一方と非接触状態であることを特徴とするプラズマ反応容器。

【請求項７】　請求項１～５の何れかにおいて、前記誘電体と前記第１及び第２の電極とが接触していることを特徴とするプラズマ反応容器。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、高効率でガスをプラズマ処理により改質するプラズマ反応容器及びガスプラズマ分解方法に関する。

【０００２】

【従来の技術】従来より、環境中の汚染ガス（例えばＮO_x、ＶＯＣ（揮発性有機化合物、Volatile Organic Compound、エチレンなどの有害物質）を浄化する方法として、例えば放電（無声放電、バリア放電）によるガスプラズマ分解処理方法が知られている。

【０００３】以下、この従来のガスのプラズマ処理方法について説明する。図１２は、ガスプラズマ処理を行う平行平板型ガス反応装置の構成図である。図１２に示すように従来の平行平板型ガス反応装置は、対向する平行金属製平板型電極０１Ａ，０１Ｂと、一方の電極（図中下面側）０１Ｂの表面に配してなる誘電体０２と、前記電極間０１Ａ，０１Ｂに高電圧を印加する高圧電源０３とから構成されており、電極間に形成される放電空間０４にプラズマ放電を発生させている。この装置によれば、電極０１Ａ，０１Ｂ間に高圧電源０３から交流高電圧を印加することにより、電極間に微小放電柱の集合体が形成され、見かけ上平板状に一様に広がった無声放電が発生し、放電空間０４に分解するガス０５を供給することで、プラズマ分解処理がなされている。この無声放電は常圧放電で一般的な雷放電に対してプラズマとガスとの接触確率（ガスの電離、励起確率）を高めることができ、反応率の向上がはかれるとされている。

【０００４】このように誘電体を電極間に挿入した無声放電を利用することにより、大気圧付近の比較的高ガス圧下においても放電体積を拡大することができ、その結果、流入ガスのプラズマ化確率が高まり、効率的にガス反応（分解）を行うことができる。

【０００５】

【発明が解決しようとする課題】しかしながら、従来技術にかかる平行平板型反応容器では、電極を積層構造にするなどの手法により、反応容器のコンパクト化を図ることは容易であるが、図１３に示すように、反応容器内を通過するガス０５の流速分布が放電空間部の電極近傍と中心部分とではガス流速に相違があるので、流速分布が不均一になる、という問題がある。この結果、高流速部（空間中心部）のプラズマ中におけるガス０５の滞在時間が短くなり、高効率の反応を行うことができない、という問題がある。

【０００６】

【課題を解決するための手段】前記課題を解決する本発明の第１の態様は、相対向する第１の平板型電極及び第２の平板型電極と、これら第１及び第２の電極間に介装される誘電体と、前記第１及び第２の電極間に電位差を付与する電位差付与手段とを備えてなり、前記第１及び第２の電極間に高電圧を印加して、導入したガスを電極間のプラズマ分解領域で分解するプラズマ反応容器において、前記誘電体の表面の両面またはいずれか一方に凸状部を複数形成してなることを特徴とするプラズマ反応容器にある。

【０００７】本発明の第２の態様は、第１の態様において、前記誘電体を介装した第１及び第２の電極を１ユニットとし、該ユニットを複数個積層してなることを特徴とするプラズマ反応容器にある。

【０００８】本発明の第３の態様は、第２の態様において、隣接するユニットの少なくとも一方の電極が共有されていることを特徴とするプラズマ反応容器にある。

【０００９】本発明の第４の態様は、第１～３の態様の何れかにおいて、前記誘電体の表面に形成した凸状部の平面形状が菱形、多角形、円、長円、楕円形状のいずれかであることを特徴とするプラズマ反応容器にある。

【００１０】本発明の第５の態様は、第１～４の態様の何れかにおいて、前記誘電体の表面に形成した凸状部の高さが一部異なることを特徴とするプラズマ反応容器にある。

【００１１】本発明の第６の態様は、第１～５の態様の

何れかにおいて、前記誘電体は、前記第１及び第２の電極の少なくとも一方と非接触状態であることを特徴とするプラズマ反応容器にある。

【００１２】本発明の第７の態様は、第１～５の何れかの態様において、前記誘電体と前記第１及び第２の電極とが接触していることを特徴とするプラズマ反応容器にある。

【００１３】

【発明の実施の形態】以下、本発明の実施の形態を説明するが、本発明はこれに限定されるものではない。

【００１４】（第１の実施の形態）図１に本実施の形態にかかるガス反応器の概略図を示す。図２は凸状部の種類を示す概略図である。

【００１５】図１に示すように、本実施の形態にかかるガス反応器は、相対向する金属製平板型である第１の電極１１Ａ及び第２の電極１１Ｂと、これら電極１１Ａ及び１１Ｂ間に介装されると共に表面に凸状部１２を有する誘電体１３とから構成されている。本実施形態では、誘電体１３の凸状部１２は、第１及び第２の電極１１Ａ及び１１Ｂと接触した状態となっている。

【００１６】また、前記電極１１Ａ及び１１Ｂの間には、図示しない電源ユニットとから交流電圧を印加することで放電空間１４内にプラズマ放電が生成されるようになっており、導入されたガス１５は、放電空間部１４内でプラズマ処理がなされてガスが改質され、改質されたガスが排出される。

【００１７】この装置によれば、凸状部が形成されているので、導入されたガスが該凸状部１２に衝突することになり、その結果ガス流速が減速され、ガス流速が均一となる結果、放電空間１４内における滞留時間が平滑面の場合よりも全体として伸び、プラズマ処理効率が向上する。また、凸状部の電界強度が高まり、バリア放電中に光量の強い局所集中放電に似た複数の放電中が混在する複合バリア放電が形成され易く、反応が促進される。

【００１８】ここで、誘電体１３に設けられた凸状部１２を両面に形成する必要がない場合には、片側のみに形成するようにしてもよい。

【００１９】なお、凸状部１２の形状は特に限定されるものではなく、ガス衝突頻度を高めることができるような形状、例えば、図２（ａ）に示すような円形状の凸状部１２Ａの他に星形状、三角形状の凸状部や、図２（ｂ）に示すような楕円形の凸状部１２Ｂを斜めに配置したものや、図２（ｃ）に示すようなＳ字形状の凸状部１２Ｃを例示することができる。また、菱形形状、多角形状、楕円形状などの適宜任意の凸状形状としてもよい。

【００２０】（第２の実施の形態）図３に本実施の形態にかかるガス反応器の概略図を示す。

【００２１】図３に示すように、本実施の形態にかかるガス反応器は、誘電体表面に形成された凸状部１２の片

側（図中下側）のみが第２の電極１１Ｂに当接しているものである。それ以外は第１の実施形態と同様であるので、同符号を付して部材の説明は省略する。

【００２２】本実施形態によって、導入されたガス分子の衝突頻度が高められ、これにより、反応効率の向上を図ることができる。

【００２３】（第３の実施の形態）図４に本実施の形態にかかるガス反応器の概略図を示す。

【００２４】図４に示すように、本実施の形態にかかるガス反応器は、誘電体表面に形成された凸状部１２の両側が相対向する電極表面から離れた非接触状態にしているものである。それ以外は第１の実施形態と同様であるので、同符号を付して部材の説明は省略する。

【００２５】本実施形態によっても、導入されたガス分子の衝突頻度が高められ、これにより、反応効率の向上を図ることができる。

【００２６】（第４の実施の形態）図５に本実施の形態にかかるガス反応器の要部概略図を示す。

【００２７】図５に示すように、本実施の形態にかかるガス反応器は、凸状部１２の高さを一部低くしてなる凸状部１７を配設してなり、第１の金属板電極１１Ａとの間に強電界部を一部分形成して局所放電を生成させ、無声放電と共に複合バリア放電を生成するようにすることもできる。

【００２８】このように、本実施形態によれば、複数の凸状部１２に一部高さの低い凸状部１７を配設させることにより、霧状バリア放電と雷状局所集中放電との複合バリア放電が可能となり、プラズマエネルギーレベルの向上を図り、ガス分解の存在により導入されたガス分子の衝突頻度が高められ、これにより、ガス反応効率の向上を図るようにしている。

【００２９】以下、本発明の好適な実施例について説明するが、本発明は何らこれらの実施例に限定されるものではない。

【００３０】（実施例１）図６に示すような装置を用い、電極への通電位置の相違によるガスの分解効率を測定した。

【００３１】本試験装置は、図６に示すように、複数のガス１、２、３を混合するガス混合器２２と、混合ガスを供給しプラズマ分解処理を施すプラズマ反応器２３と、該プラズマ反応器に高電圧を印加する高圧電源２４と、分解されたガスを測定するガス分析装置２５とから構成されている。

【００３２】誘電体表面に形成する凸状部１２の形状を、図７～図９に示すように種々変化させ、それぞれを用いてCO_2の分解試験を行った。本実施例の試験結果を、表１及び図１０に示す。

【００３３】本実施例にかかるCO_2ガス分解条件を以下に示す。

・ガス組成：CO_2（１０％）＋O_2（１０％）／Ｎ

$_2$（バランス）
・ガス流量：２００～１０００ｃｃ／分
・目的反応：CO_2の分解反応（CO_2→ＣＯ＋１／２O_2）
・反応容器形式
・電極寸法：２０ｍｍ×５０ｍｍ
誘電体材質：AL_2O_3
反応容器体積：２８６ｃｃ
【００３４】(1)凸状部（片側、円形状）付誘電体（片側接触）（図７参照）
誘電体厚み：０．５ｍｍ
凸状部高さ：０．２５ｍｍ
凸状部径：２ｍｍ
＊【００３５】(2)凸状部（両側、円形状）付誘電体（両側非接触）（図８参照）
誘電体厚み：０．５ｍｍ
凸状部高さ：０．２５ｍｍ
【００３６】(3)凸状部（片側、長円形状）付誘電体（両側接触）（図９参照］
誘電体厚み：０．５ｍｍ
凸状部高さ：０．２５ｍｍ
凸状部径：２ｍｍ（短径）、３ｍｍ（長径）
【００３７】(4)平滑面誘電体　（図１２参照）
誘電体厚み：０．５ｍｍ
【００３８】
＊ 【表１】

	ガス流量（ｍＬ／ｍｉｎ）				
	２００	４００	６００	８００	１０００
（４）（従来法）	８	４．１	１．７	０．８	０．６
（１）	２４．３	１８．２	１３．６	１１．９	１０．５
（２）	２９．５	２３．１	１８．１	１５．３	１２．８
（３）	３５．４	２５．９	２０．９	１８	１６．４

【００３９】表１及び図１０に示すように、（１）から（３）の凸状部を形成した場合には、（４）の従来のものに比較してプラズマガス分解率がいずれも高いものであった。
【００４０】また、本発明にかかる（３）及び（４）の反応容器は、（２）の容器よりも放電体積が少ないにもかかわらず高い反応率を示した。
【００４１】（実施例２）上記（１）から（４）の種々のプラズマ反応容器を用い、NO_xの分解試験を行った。
【００４２】本実施例にかかるNO_xガス分解条件を以下に示す。
・ガス組成：ＮＯ（５００ｐｐｍ）＋O_2（１０％）／N_2（バランス）
・ガス流量：５００ｃｃ／分
・電源：電圧（２．８ｋＶｐ）,周波数（１０ｋＨｚ），波形（矩形波）
誘電体材質：Al_2O_3（接地側電極側へ配設）
誘電体厚さ：０．５ｍｍ
電極材質：ＳＵＳ
電極寸法：５０ｍｍ×２０ｍｍ（長手方向がガス流れ方向）
放電間隔：１.５ｍｍ
【００４３】本実施例の試験結果を、表２及び図１１に示す。
【００４４】
【表２】

	ガス流量（ｍＬ／ｍｉｎ）				
	２００	４００	６００	８００	１０００
(4) (従来法)	２６	１４	６	２	１
(1)	７９	６８	６１	５８	５６
(2)	８８	８２	７８	７５	７３
(3)	１００	９５	９２	８９	８７

【００４５】表２及び図１１に示すように、（１）から（３）の凸状部を形成した場合には、（４）の従来のものに比較してプラズマガス分解率がいずれも高いものであった。

【００４６】また、本発明にかかる（３）及び（４）の反応容器は、（２）の容器よりも放電体積が少ないにもかかわらず高い反応率を示した。

【００４７】

【発明の効果】本発明によれば、誘電体の表面に凸状部が形成されているので、導入されたガスが該凸状部に衝突することになり、その結果ガス流速が減速されてガス流速が均一となり、放電空間内の滞留時間が平滑面の場合よりも全体として伸び、プラズマ処理効率が向上し、高効率でガスの改質が可能となる。

【図面の簡単な説明】

【図１】第１の実施の形態にかかるプラズマ反応容器の概略図である。

【図２】凸状部の形状を示す概略図である。

【図３】第２の実施の形態にかかるプラズマ反応容器の概略図である。

【図４】第３の実施の形態にかかるプラズマ反応容器の概略図である。

【図５】第４の実施の形態にかかるプラズマ反応容器の＊＊概略図である。

【図６】本実施例に試験装置の概略図である。

【図７】本実施例にかかる凸状部の構成を示す図である。

【図８】本実施例にかかる凸状部の構成を示す図である。

【図９】本実施例にかかる凸状部の構成を示す図である。

【図１０】実施例にかかるCO_2分解率のグラフである。

【図１１】実施例にかかるNO_xの分解率のグラフである。

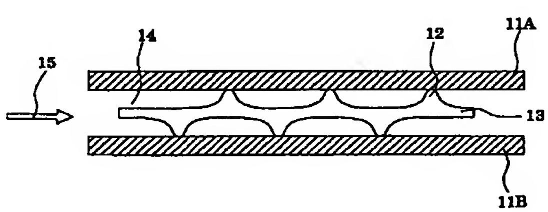
【図１２】平行平板型反応容器の概略図である。

【図１３】平行平板型反応容器内のガスの流速の概略図である。

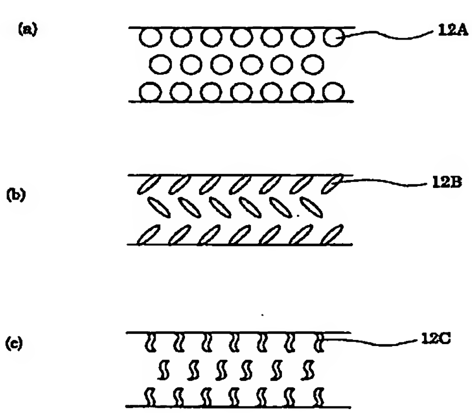
【符号の説明】

１１Ａ　第１の金属製平板型電極
１１Ｂ　第２の金属製平板型電極
１２　誘電体
１３　電源
１４　放電空間部
１５　ガス

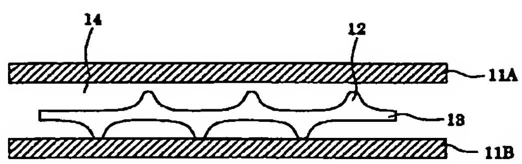
【図１】



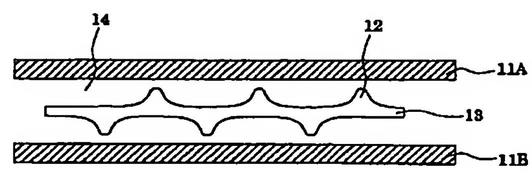
【図２】



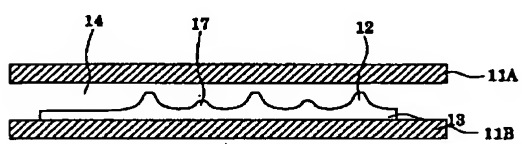
【図３】



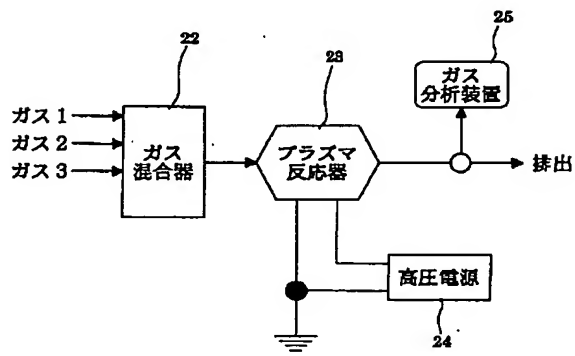
【図４】



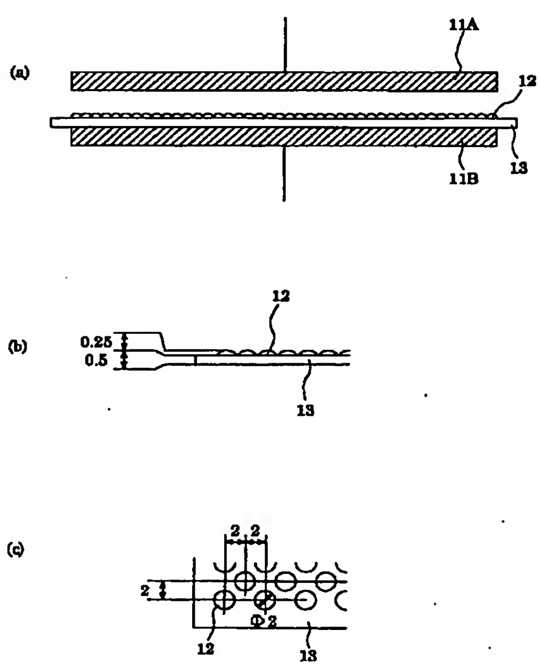
【図５】



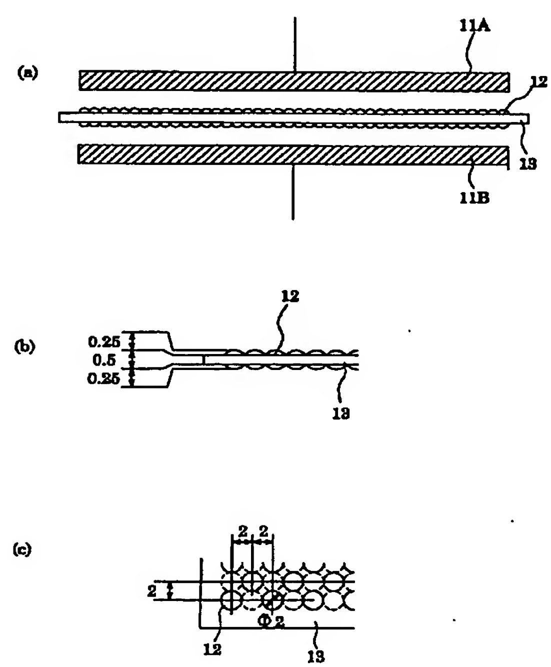
【図６】



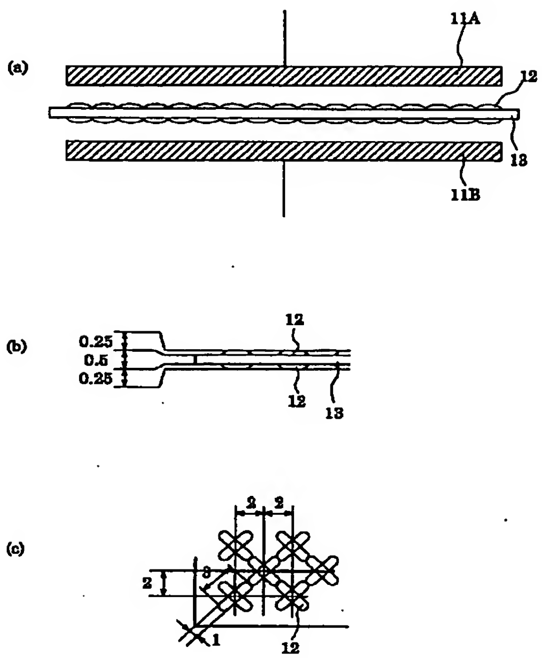
【図７】



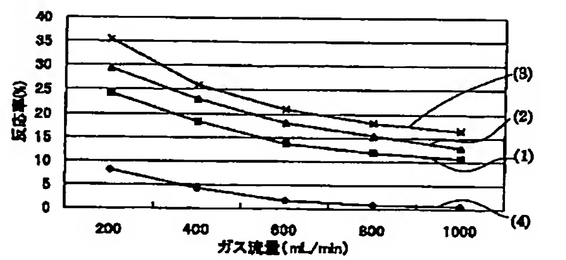
【図８】



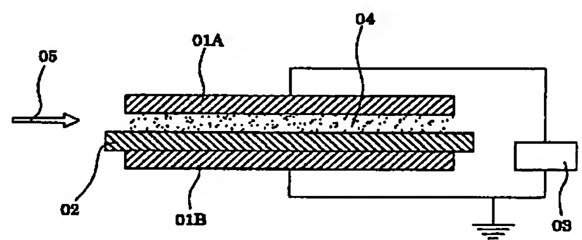
【図９】



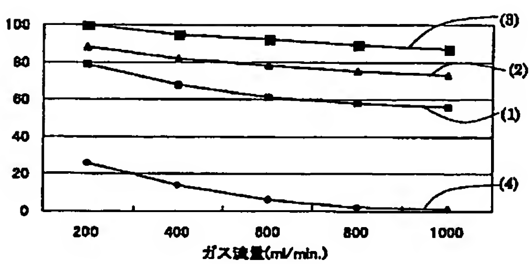
【図１０】



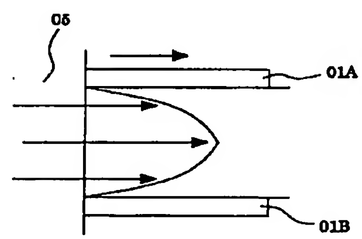
【図１２】



【図１１】



【図１３】



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